Community Based Irrigation Design and Performance in Tigray

by

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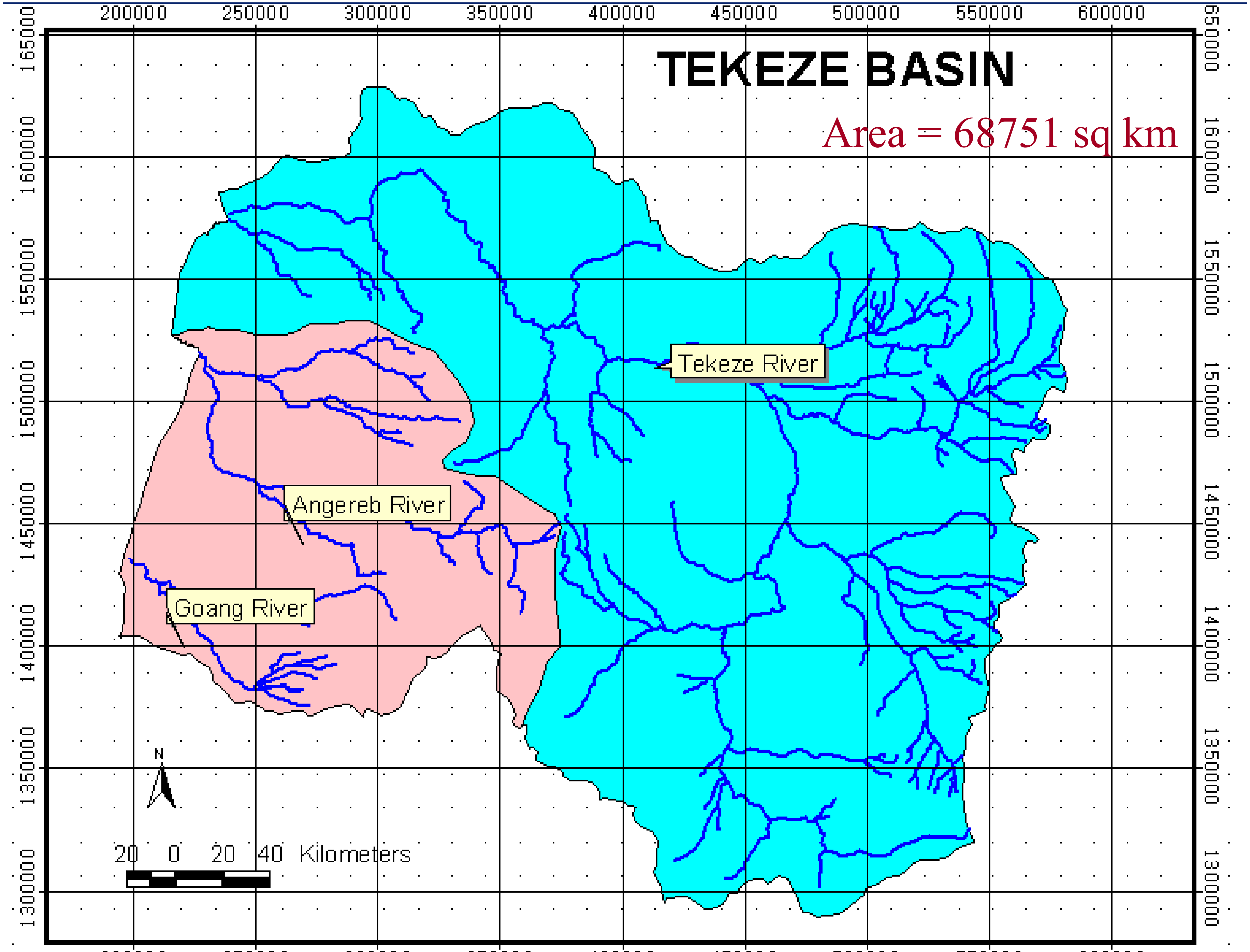
TEKEZE BASIN
Area = 68751 sq km
Tekeze River
Angereb River
Goang River
N
20 0 20 40 Kilometers
200000 250000 300000 350000 400000 450000 500000 550000 600000
1650000 1600000 1550000 1500000 1450000 1400000 1350000 1300000

TEKEZE BASIN
Tigray
Amhara
Tekeze River
Angereb River
Goang River
N
20 0 20 40 Kilometers
200000
250000
300000
350000
400000
450000
500000
550000
600000
1650000
1600000
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1350000
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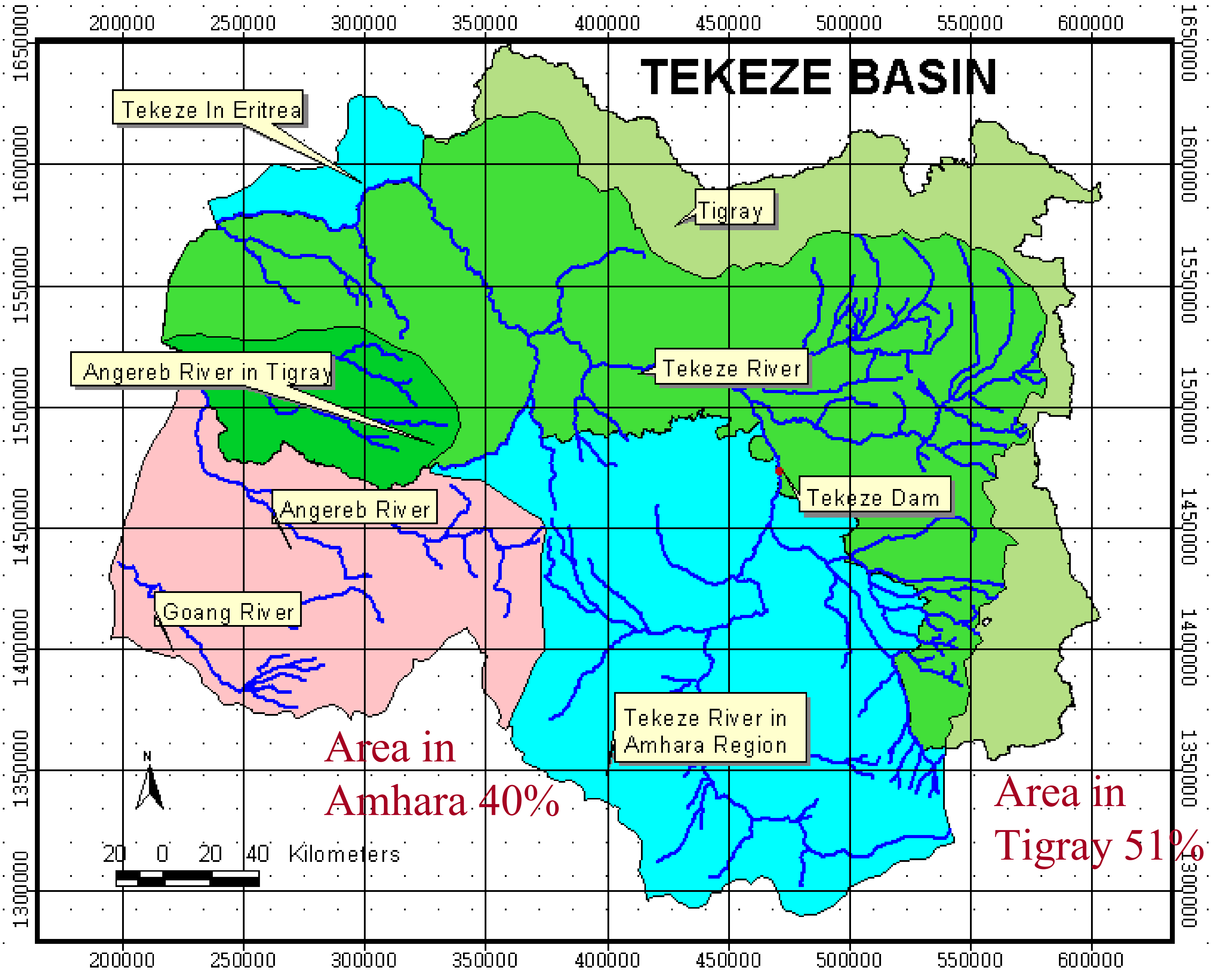


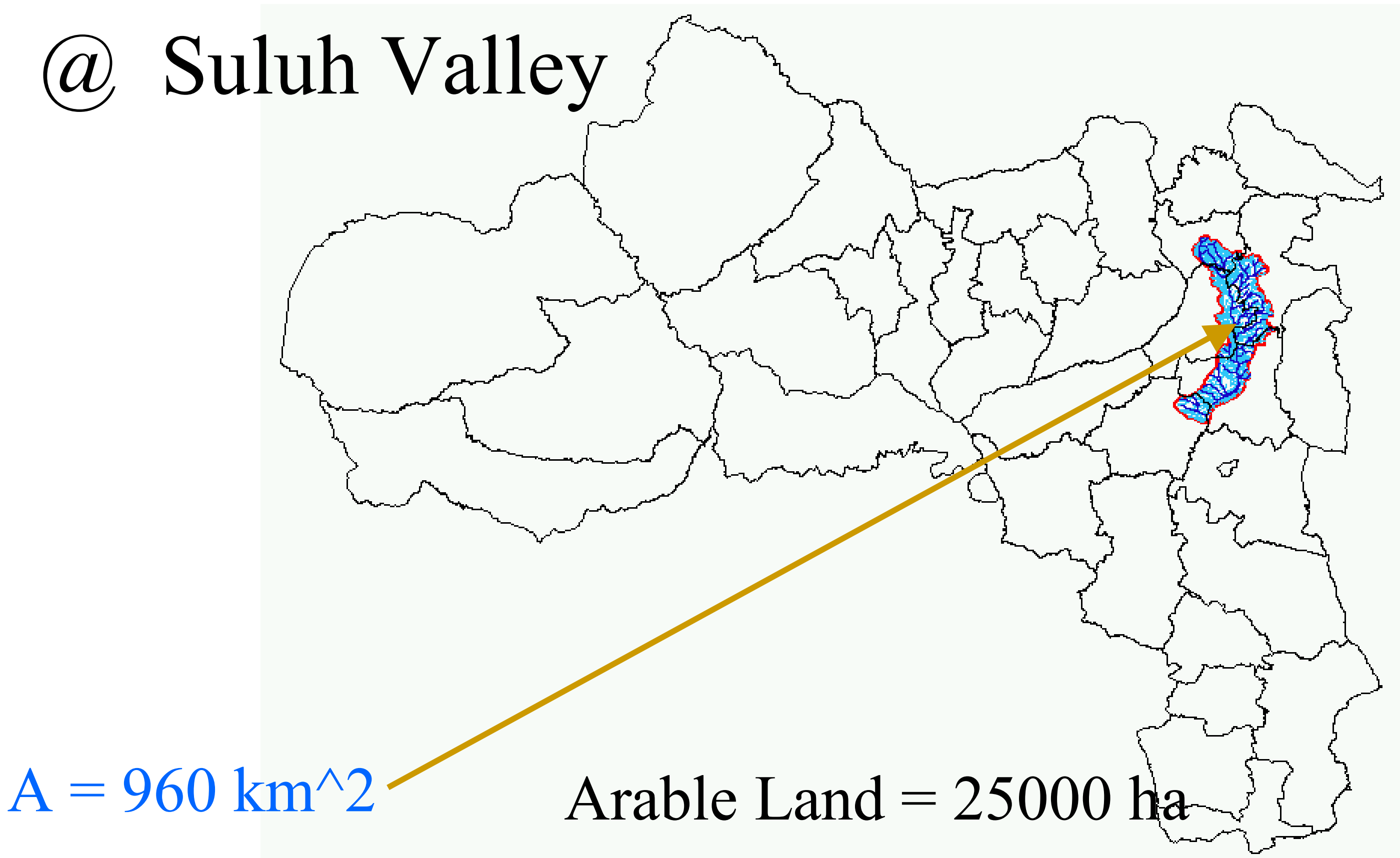
TEKEZE BASIN
Tekeze In Eritrea
Tigray
Angereb River in Tigray
Tekeze River
Tekeze Dam
Angereb River
Goang River
Tekeze River in Amhara Region
Area in Amhara 40%
Area in Tigray 51%
N
20 0 20 40 Kilometers
200000 250000 300000 350000 400000 450000 500000 550000 600000
1650000 1600000 1550000 1500000 1450000 1400000 1350000 1300000

Topography

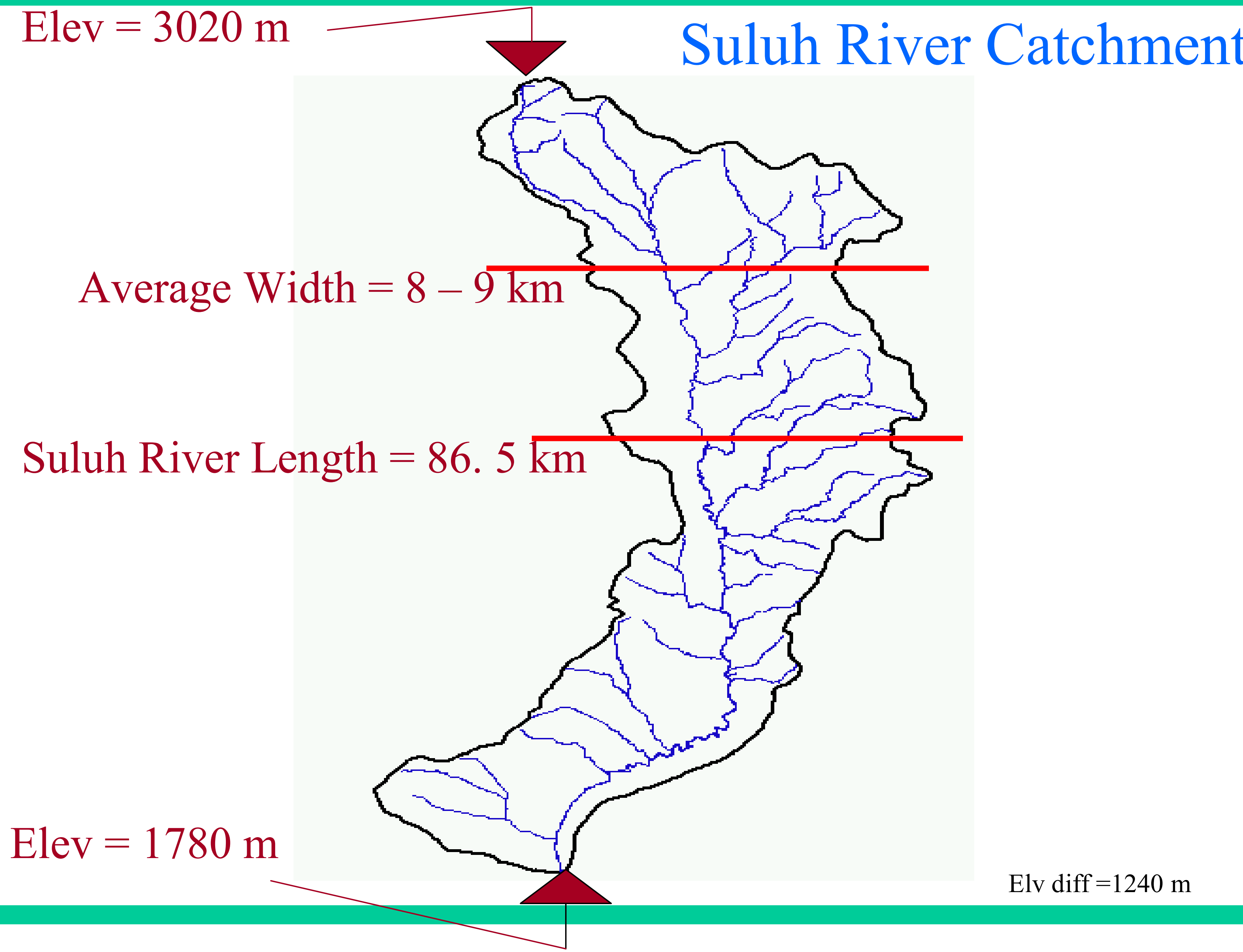
- 70% …… > 1500 m asl
- 40% …… > 2000 m asl
- Low Land …. = Flat Plain 1500 sq km
- High Land ….
  - Mountains, Deep Gorges
  - Plateaus
  - Undulating Slopes

Typical Cross section of a Valley in the High Land

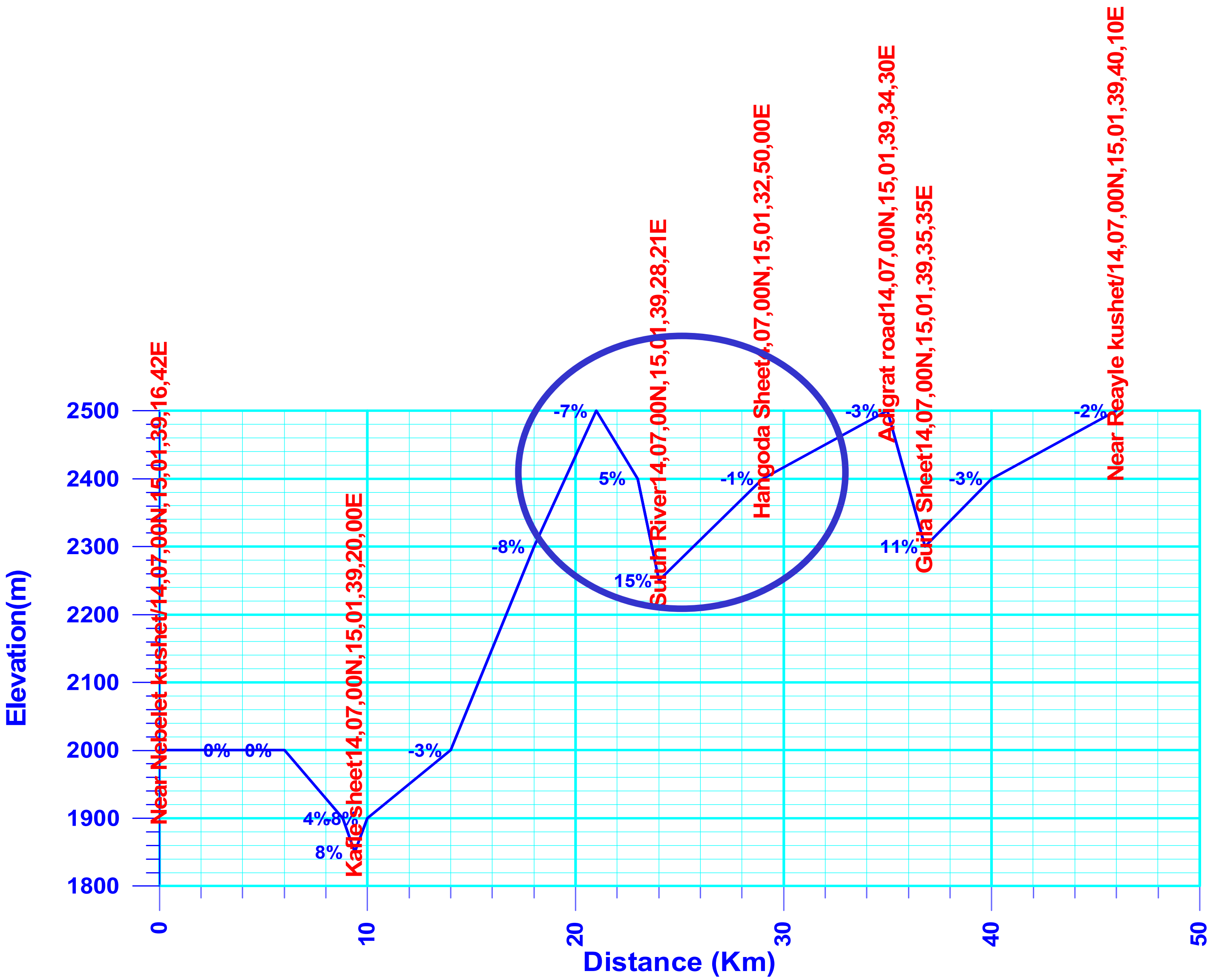
@ Suluh Valley



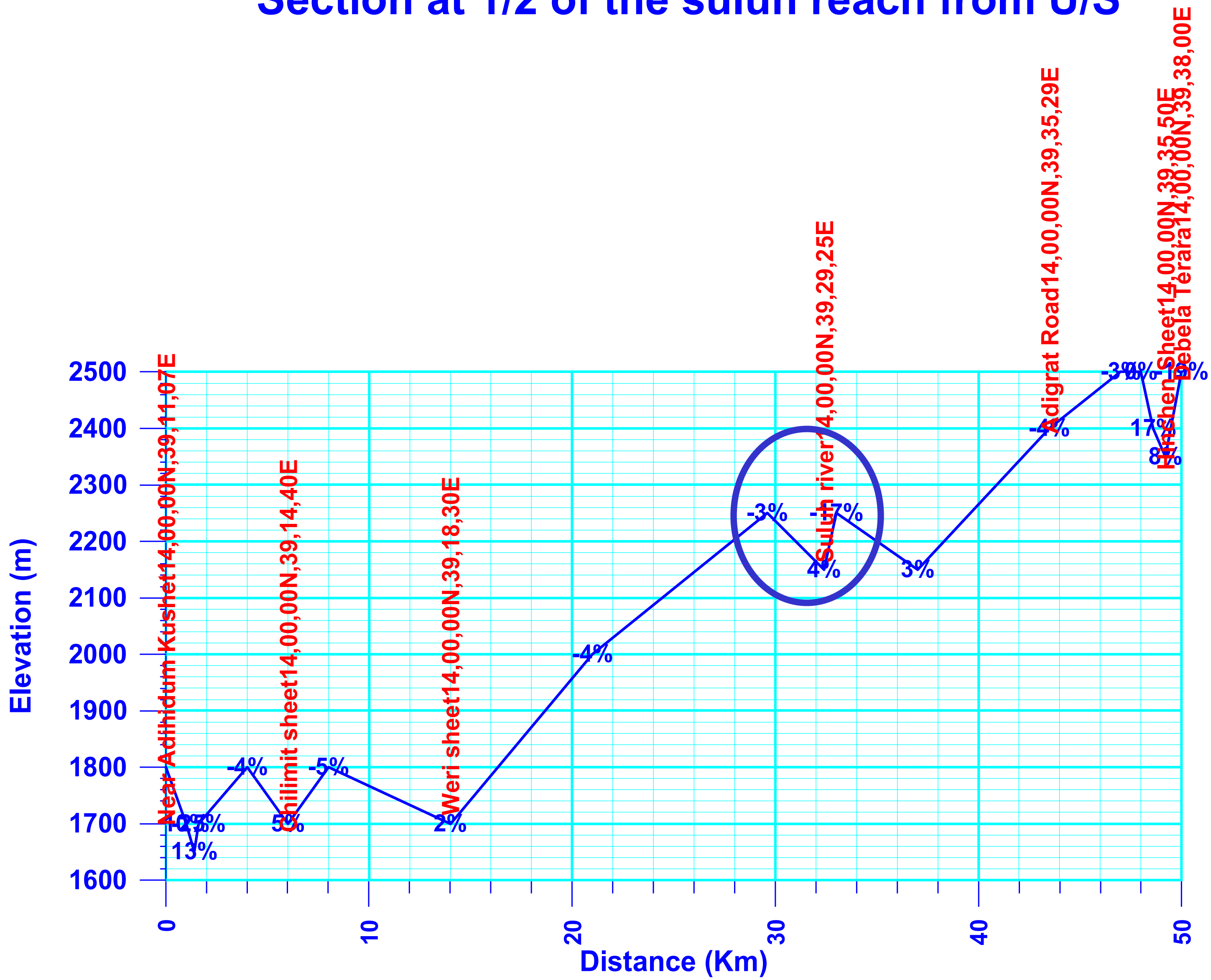
Suluh River Catchment



Section at 1/3 of the suluh reach from U/S



Section at 1/2 of the suluh reach from U/S



Irrigation Experience

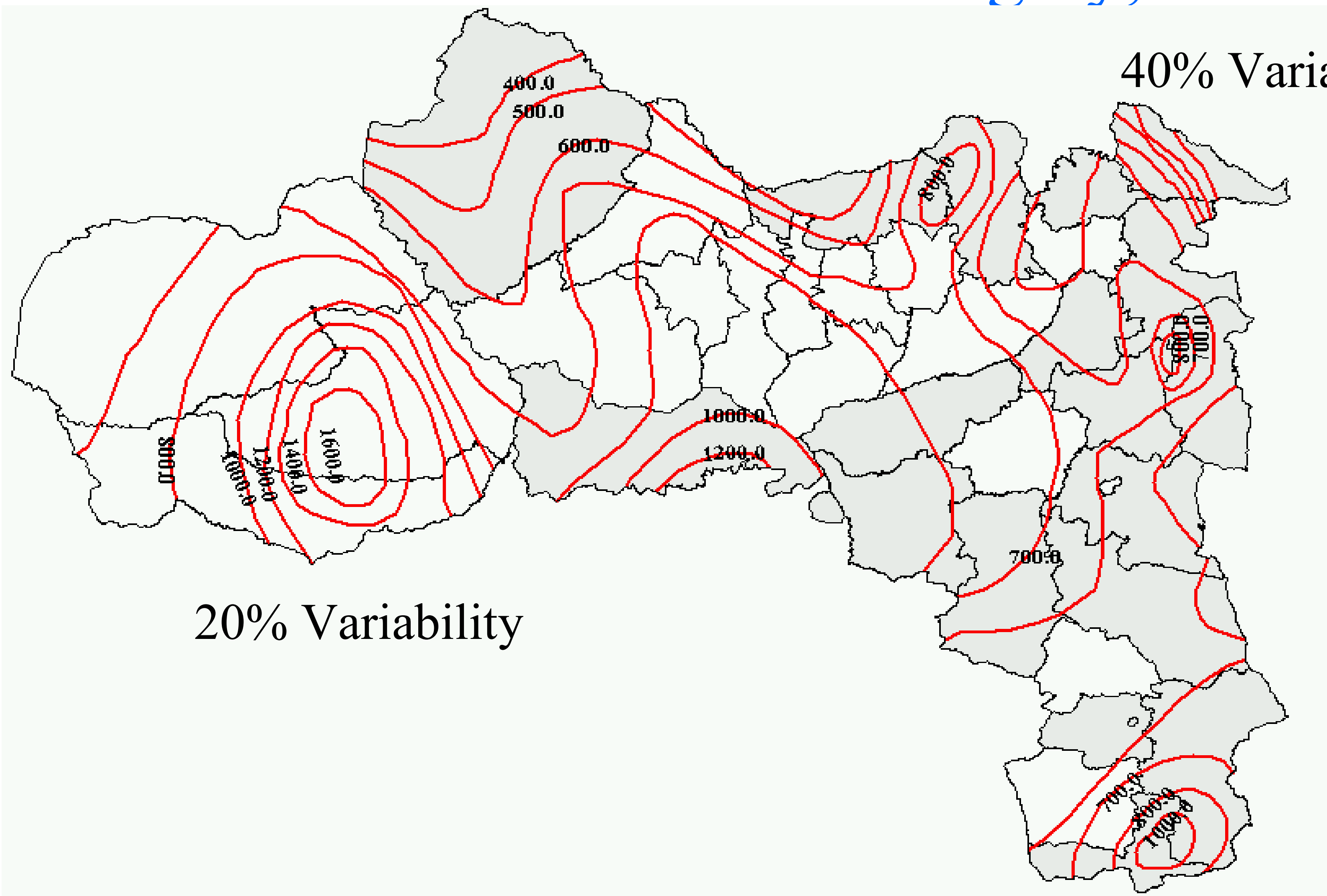
- Over 466 Indigenous Irrigation Schemes
  - 3492 ha
  - Over 100 years old

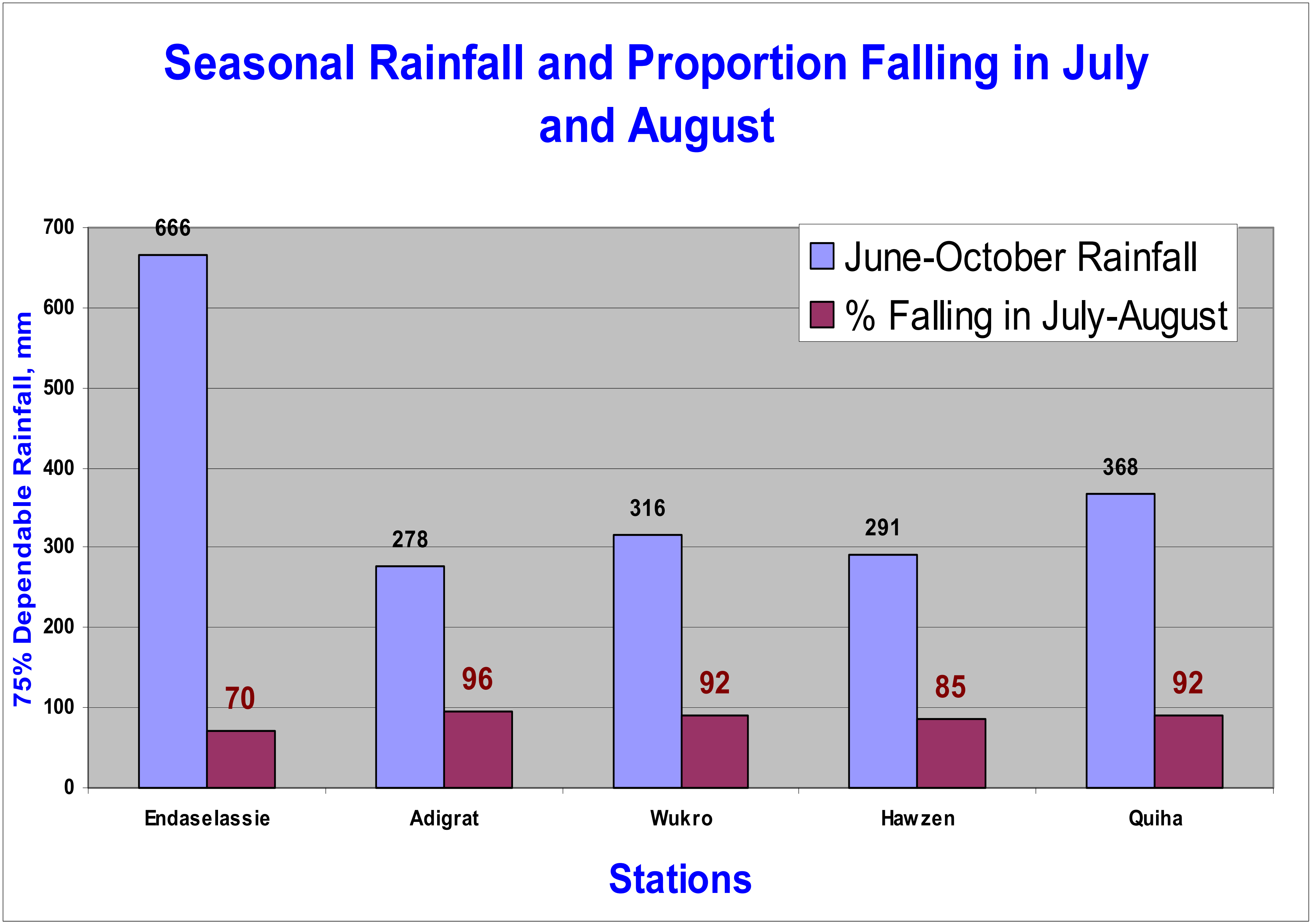
Over 56 Irrigation Schemes (3845ha) Designed & Constructed by COSAERT

Need for Irrigation : Productivity of Rain-fed Agriculture

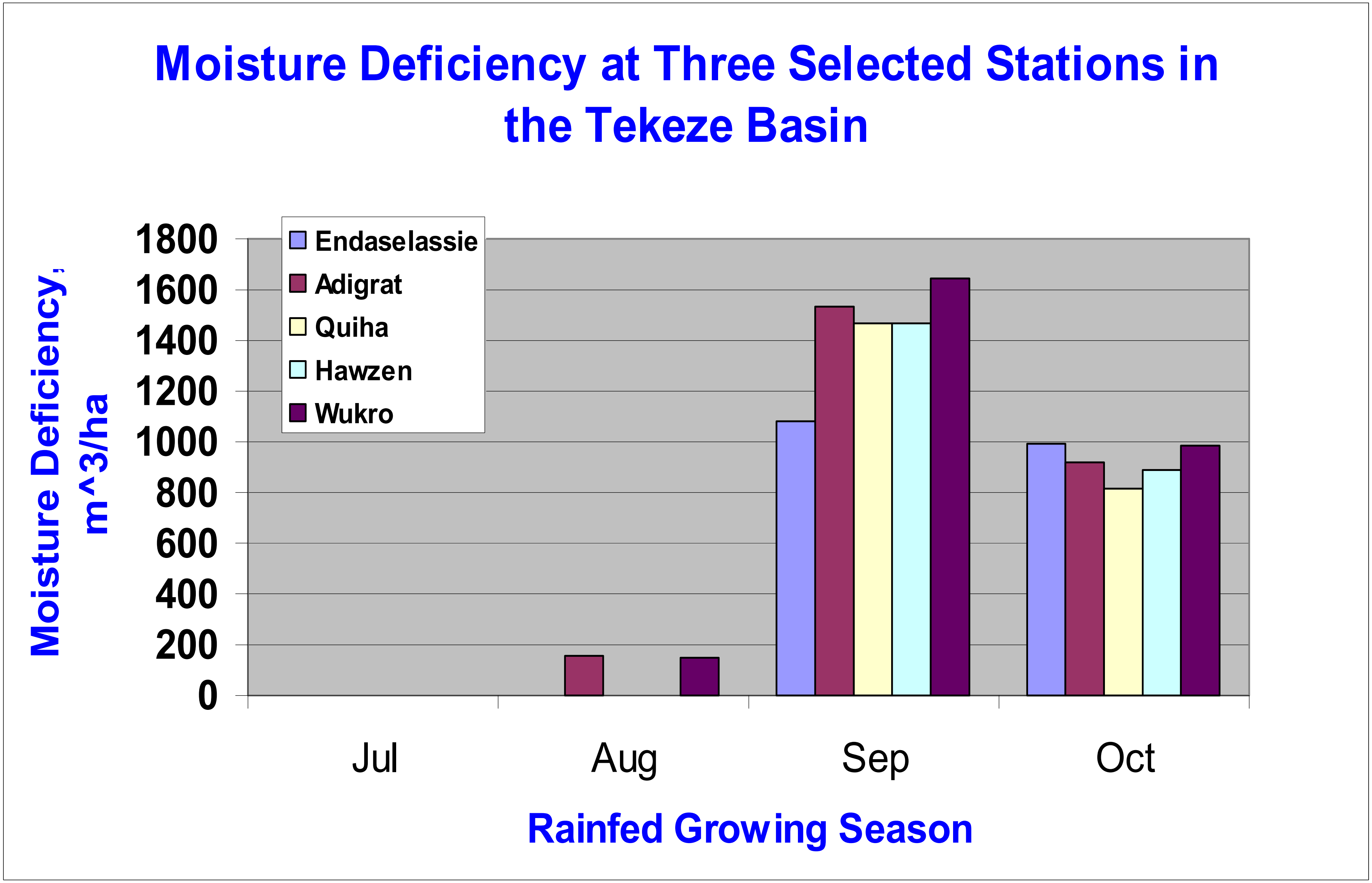
Crop	Average Crop Yield, Qt/ha	
	High Rainfall Area	Low Rainfall Area
Wheat	20 – 25	7 – 11
Maize	50 – 55	8 - 11

Mean Annual Rainfall in Tigray, mm





Seasonal Rainfall and Proportion Falling in July and August
75% Dependable Rainfall, mm
0
100
200
300
400
500
600
700
666
70
278
96
316
92
291
85
368
92
Endaselassie
Adigrat
Wukro
Hawzen
Quiha
Stations
June-October Rainfall
% Falling in July-August



Moisture Deficiency at Three Selected Stations in the Tekeze Basin
Moisture Deficiency, m^3/ha
1800
1600
1400
1200
1000
800
600
400
200
0
Endaselassie
Adigrat
Quiha
Hawzen
Wukro
Jul
Aug
Sep
Oct
Rainfed Growing Season

Challenges in the Promotion of Irrigation in the Tekeze Basin

- Limitations in the source of irrigation water;
- Big capital required (Reservoirs, Pumps…)
- Absence of locally developed design parameters;
- Inadequate extension support in irrigation agronomy & water management;
- Unattractive market to agricultural Produce.

Limitations with source of irrigation water

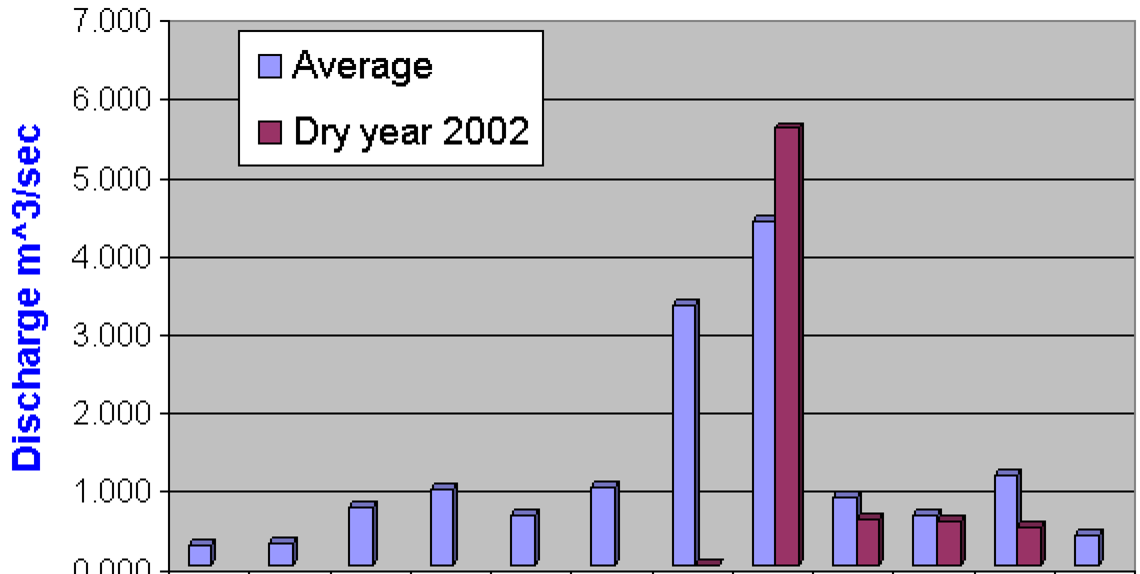
- Perennial Streams ….. Few in No. & Low Q
- Ground Water ….. Only for Domestic Use
- Rain Water Harvesting ….. Needs Expensive Structure

Limitations with Perennial Streams

- Tekeze Q @ international border = 2 cumsec
- Tributaries Q …….. 0-70 l/s

Effect of the 2002 Drought on Surface Water Yield

Figure 4 Suluh River Monthly Discharge of 2002 Compared to Average of Previous Years

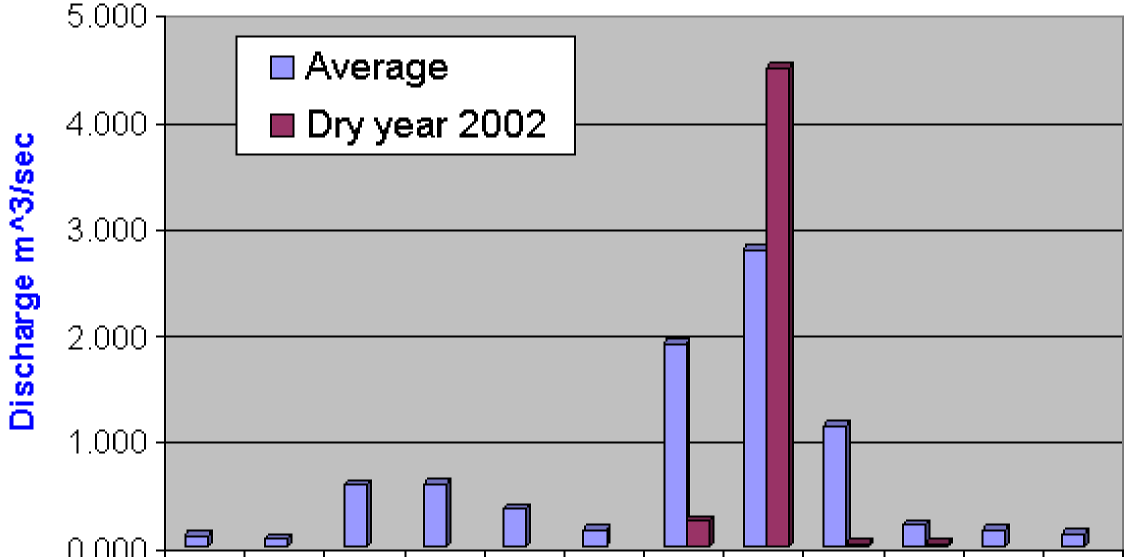


	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Average	0.26	0.29	0.74	0.97	0.63	0.99	3.33	4.40	0.87	0.64	1.15	0.40
Dry year 2002							0.01	5.58	0.59	0.57	0.5	

Month

Effect of the Drought on Surface Water Yield

Figure 5 Ilalla River Monthly Discharge of 2002 Compared to Average of Previous Years



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Average	0.10	0.07	0.57	0.58	0.35	0.15	1.89	2.78	1.12	0.20	0.15	0.11
Dry year 2002							0.24	4.49	0.03	0.03		

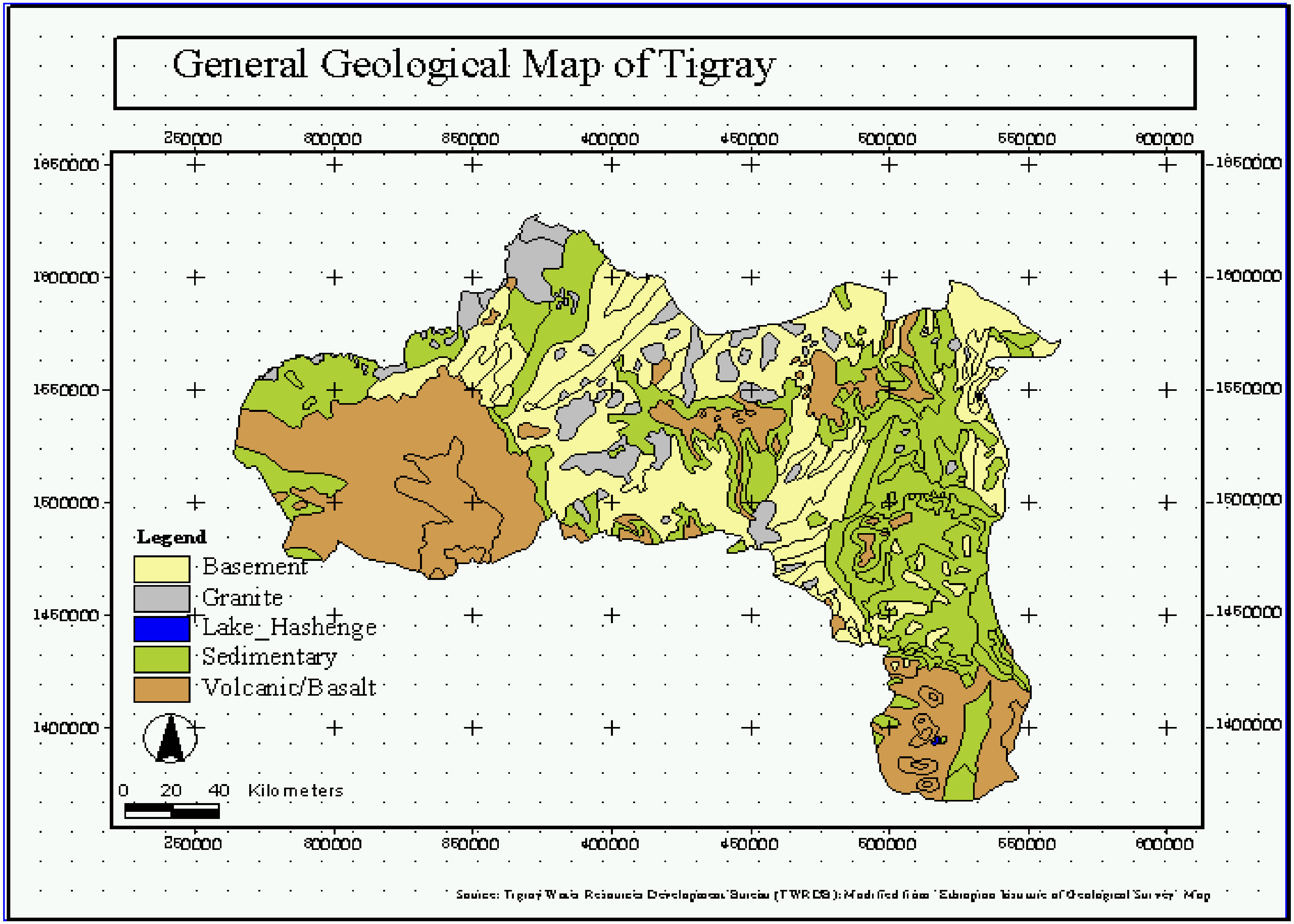
Month

Limitations with Perennial Streams

- ➔Little Irrigation Potential
  - A survey in 2000
    - 466 irr. Schemes …. Irrigating 3492 ha
    - Potential to expand by … ……5272 ha
    - Total Potential ……… 8764ha or 0.87% of the total arable land
      - ➔Low potential though Exaggerated Figure !

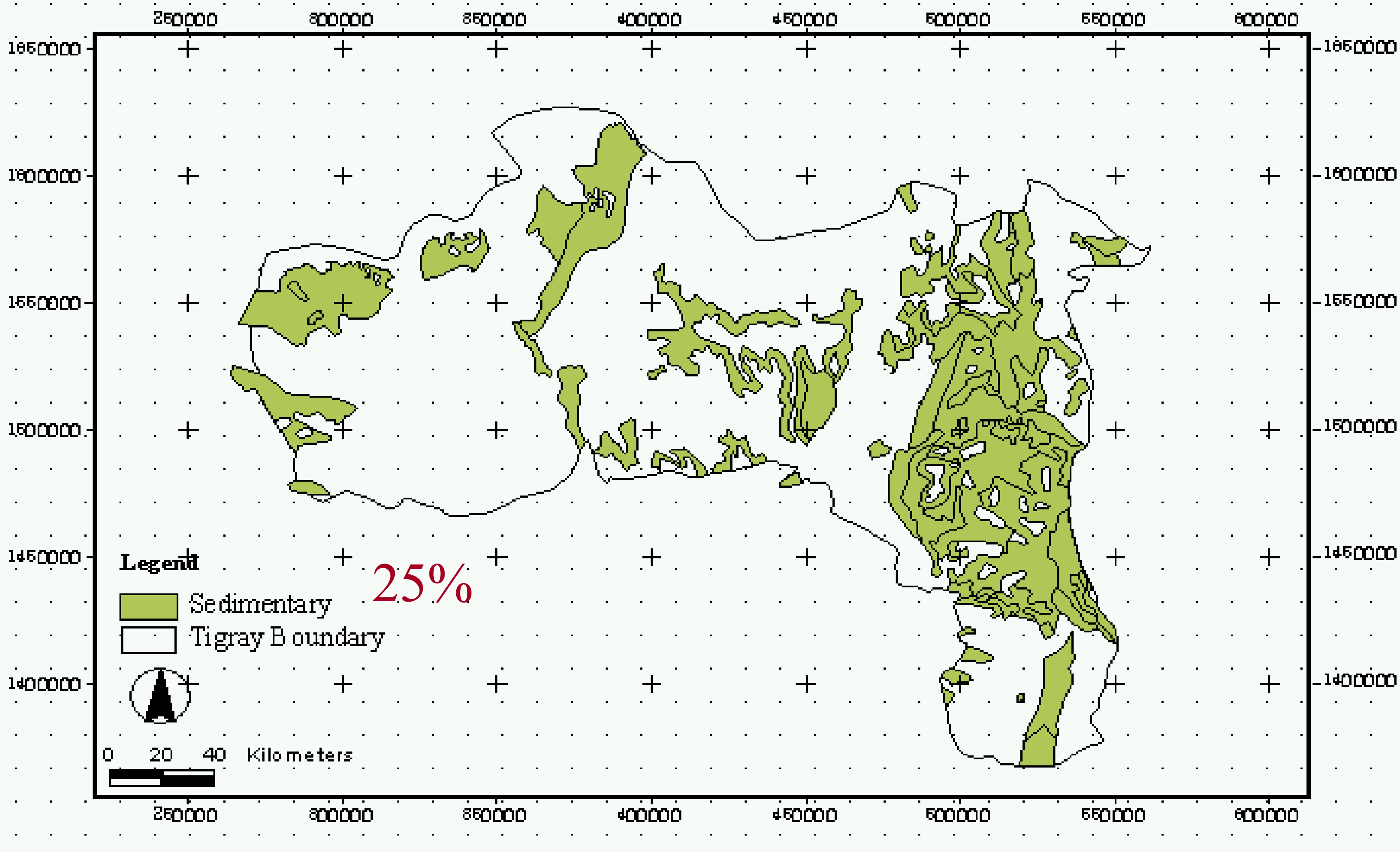
Limitations with Ground Water

- ➔ Little Potential

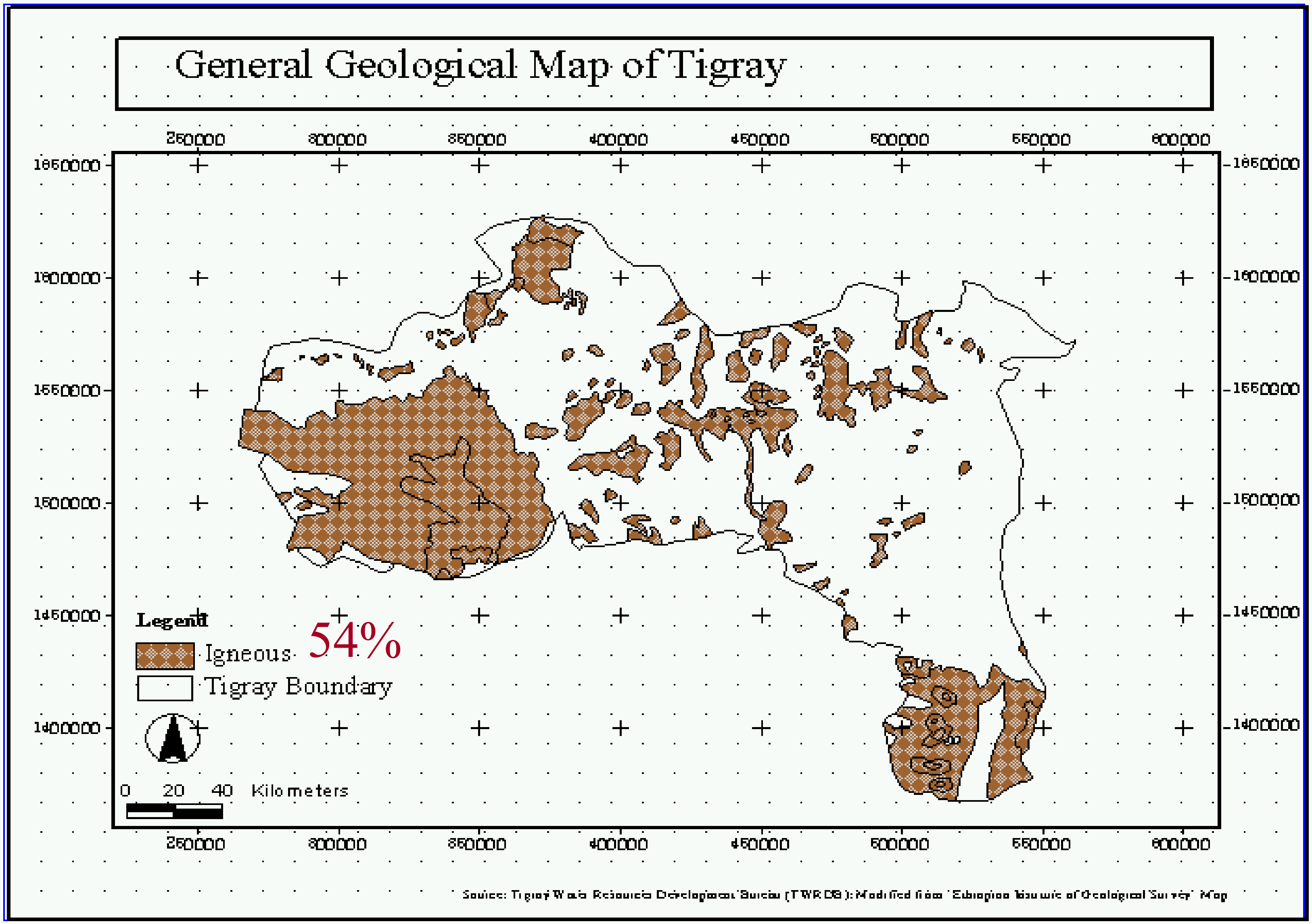


General Geological Map of Tigray
Legend
Basement
Granite
Lake_Hashenge
Sedimentary
Volcanic/Basalt
0 20 40 Kilometers
250000
300000
350000
400000
450000
500000
550000
600000
1650000
1600000
1550000
1500000
1450000
1400000

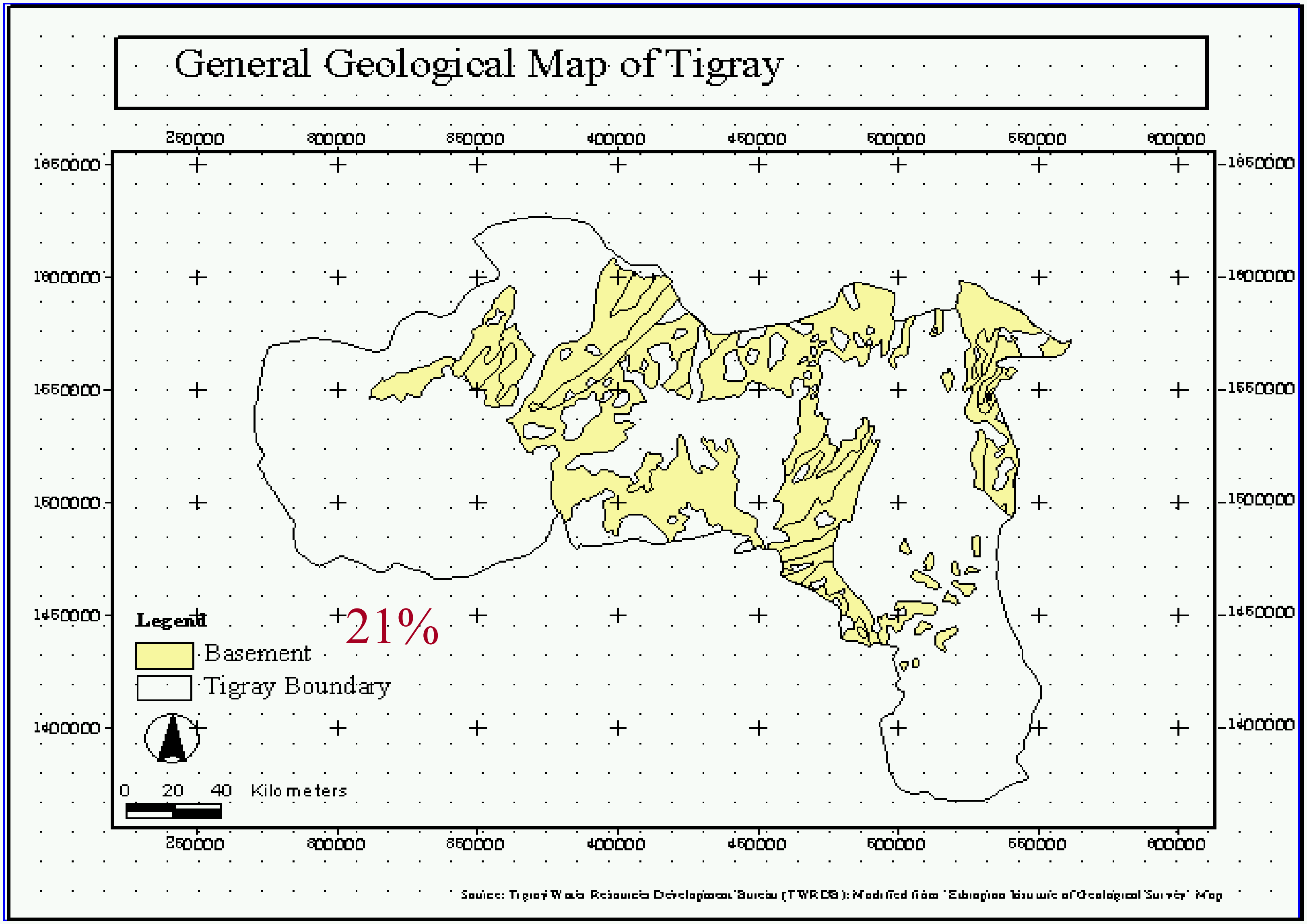
General Geological Map of Tigray



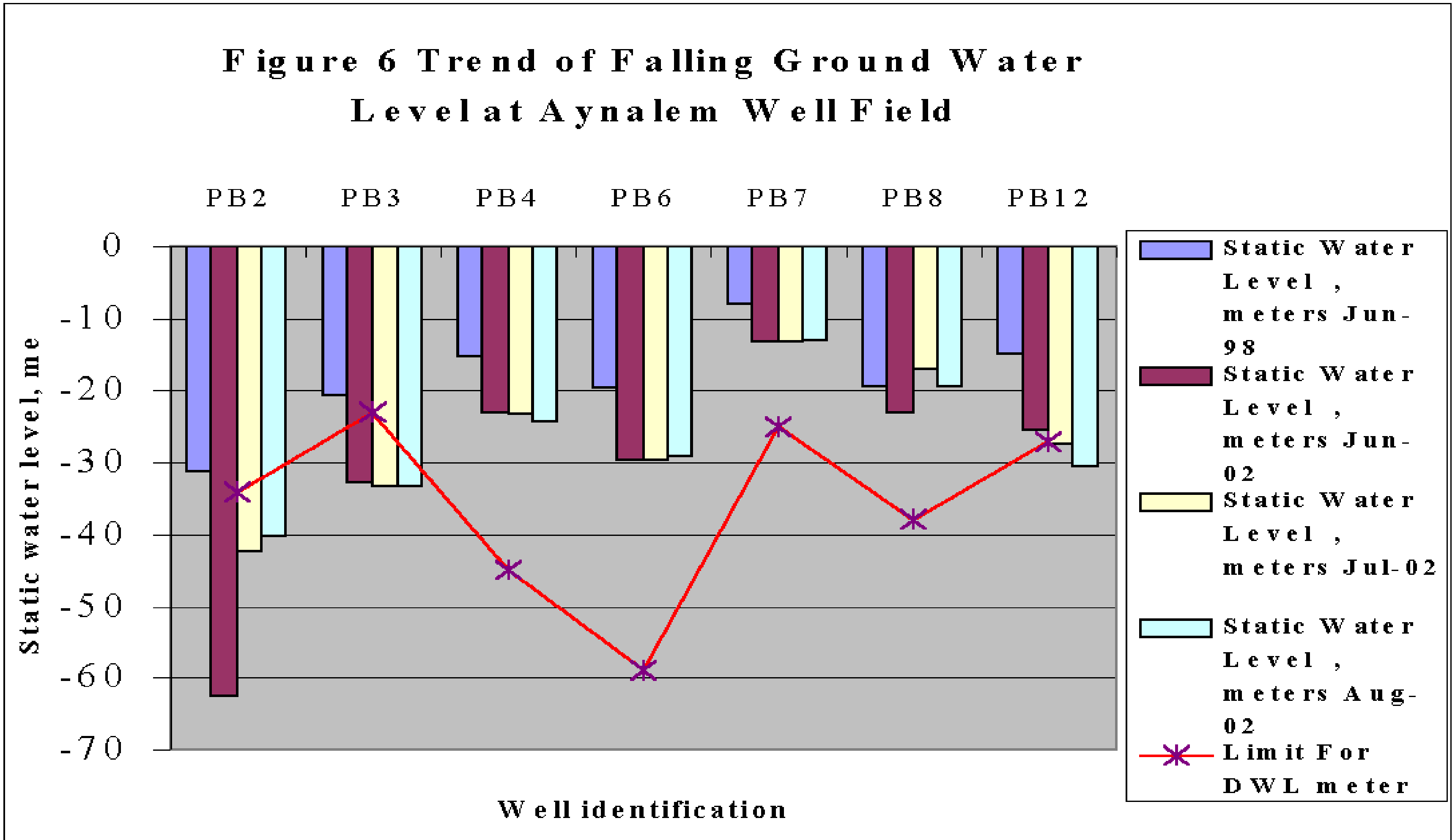
Source: Tigray Water Resource Development Bureau (TWRDB): Modified from 'Ethiopian Institute of Geological Survey' Map



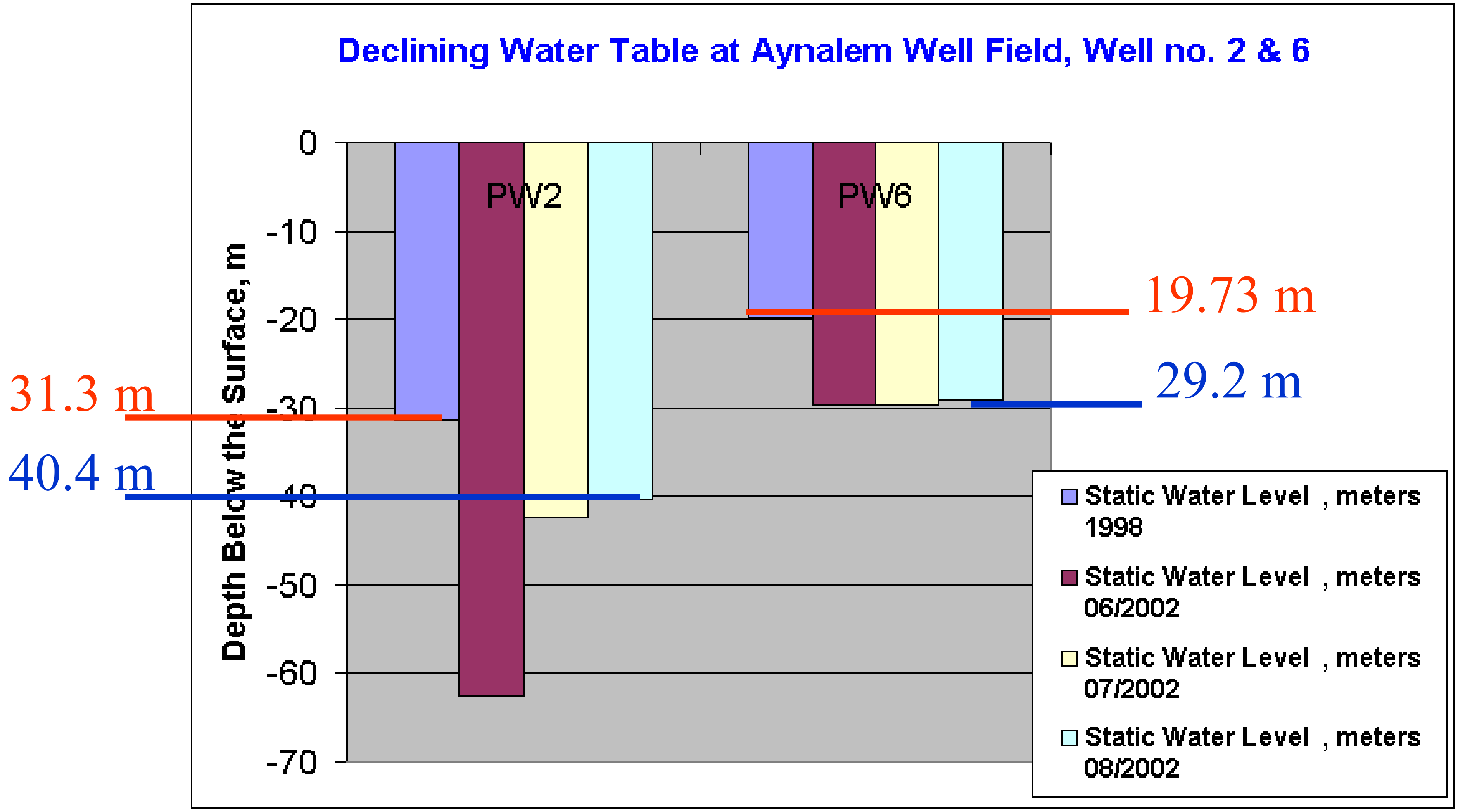
General Geological Map of Tigray
250000
300000
350000
400000
450000
500000
550000
600000
1650000
1600000
1550000
1500000
1450000
1400000
Legend
Igneous
54%
Tigray Boundary
0 20 40 Kilometers


General Geological Map of Tigray
Legend
Basement
Tigray Boundary
0 20 40 Kilometers
21%

Effect of Drought at Aynalem Well Field



GW Declining Rate 1 – 1.5 m/Year



2.23m/yr

Preliminary Observation over the Entire Well Field: Declining Rate @ 1–1.5m/yr

2.34m/yr

Ground Water

- About 75 of the region, covered by igneous and basement,➔ has little or no ground water potential.

- Recharge Rate is Very Low.

- Therefore, the possibility of utilizing ground water for irrigation is very remote.

Limitations with Rain Water Harvesting

- Cases with Small Ponds

- Cases With Reservoir Dams

Volume = 150 – 185 cu. M   Irrigable Area = 500 –1000 sq m

- ➔ For Supplementary Irrigation
- ➔ Owned by a Family

Limitations with Ponds

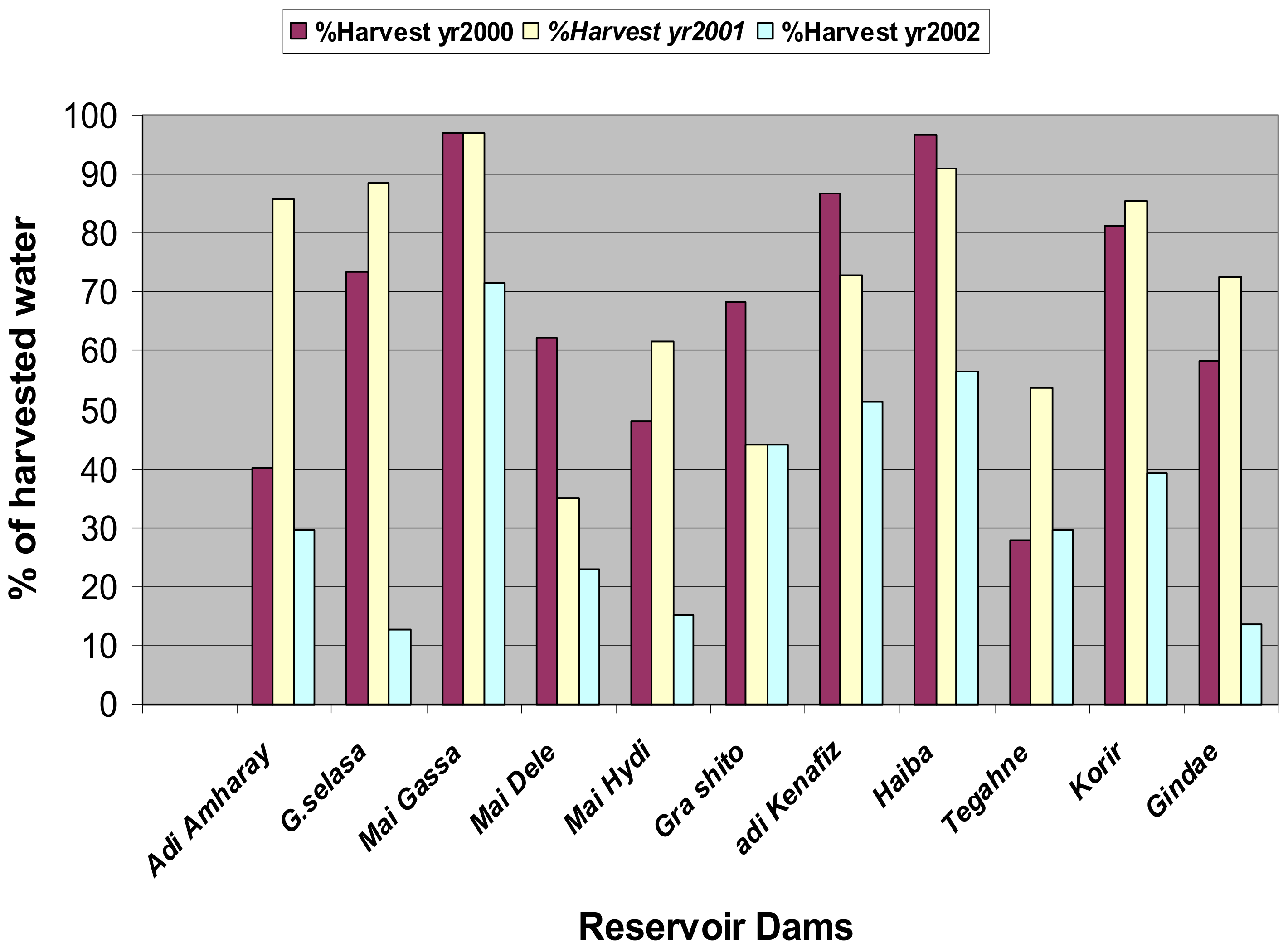
- Seepage Problem
- Smallness of the Irrigated plot (0.1 ha)
  - Assuming a Wheat yield of 20 –30 qt/ha
    - Obtainable Production = 2 – 3 qt/ha
    - Food demand/Family of 5 is > 10 qt

- ➔Either the pond size has to be increased or the family has to look for other source of income.

Limitations With Reservoir Dams

- Seepage
- Runoff Harvest Failure
- Capital Intensive

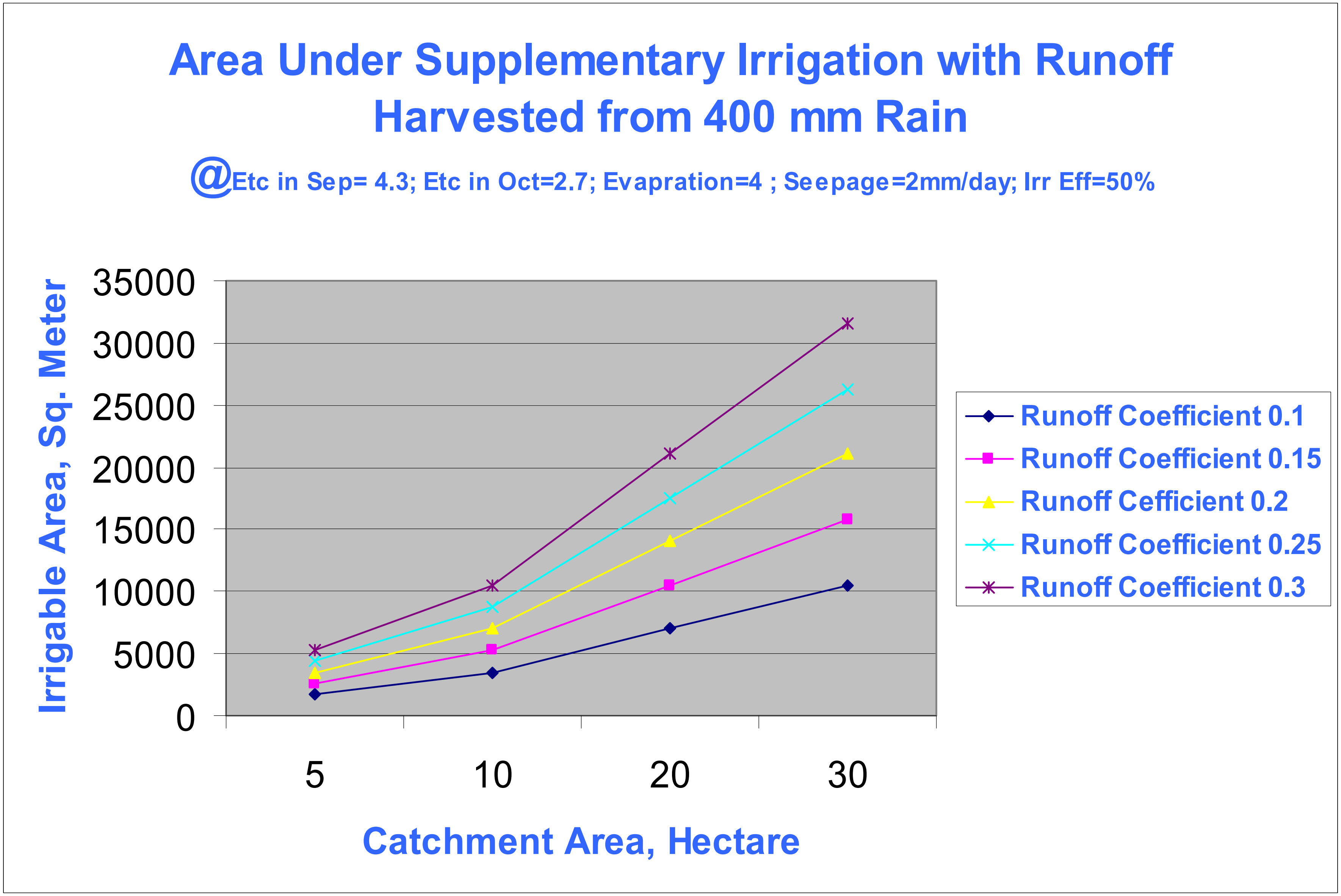
Figure 3 Percentage of Harvested Water by Reservoirs as compared to their Design capacity



Causes of Runoff Harvest Failure

- Shortage of Rainfall / Drought
- Rain shadow effect
- Over Estimation of Runoff Coefficient

Over Estimation of Runoff Coefficient



Irrigation Performance

- Cropping Pattern
- Water Use Efficiency

Cropping Pattern

Table 1 Irrigation Cropping Pattern as Collected in 1999 and 2001

Crop type	Year of Data Collection 1999 average of six Dams	2001 Average of Nine Dams
Maize	49.2	89.5
Onion	21.9	5.7
Teff	9.6	
Pepper	5.1	0.7
Barley	4.3	
Chick Pea	3.1	0.6
Tomato	2.8	2.7
Wheat	1.7	
Millet	0.7	
Fenugreek	0.6	
Field Peas	0.3	
Faba	0.3	
Bean	0.3	
Lettuce		0.6
Potato		0.2
Beet Root		

Farmers' reason for growing more of maize

- Maize can be consumed directly and the stalk can be source of feed and fuel.
- It is less laborious and not perishable.
- The seed and pesticides required for growing horticulture are expensive and not available easily.

Implication of the Existing Cropping Pattern

- The irrigation schemes are not yet developed up to their capacity where benefit is the highest per unit volume of water.

- Under such conditions, it would be difficult for the irrigators to cover the O&M costs let alone to recover the investment fully or partially.

Key Research Issues

- ➔ At the Source of Water
- ➔ In the Conveyance System
- ➔ In the Irrigation field (Water use System)
- ➔ Issues for Sustainability

Research Need at the Source of Water

- 1. Determination of rainfall-runoff relationship;
- 2. Determination of reservoir sedimentation rate and its mitigation measures;
- 3. Supplementary irrigation as the center of maximizing water productivity in semi arid areas;
- 4. Effect of excessive dewatering of shallow wells on productivity of grass land; and
- 5. Effect of reservoir dams in restoring downstream stream flow.

In the Conveyance System

- Topographic advantage for using piped flow for conveyance and distribution of irrigation water.

- Low cost options for mitigating conveyance losses

Research In the Irrigation field (Water use System)

- Water use efficiency in a field with 5 - 15m furrow length
- Irrigation under a condition of water scarcity.
- Matching cropping calendar with the period having the least irrigation water requirement.

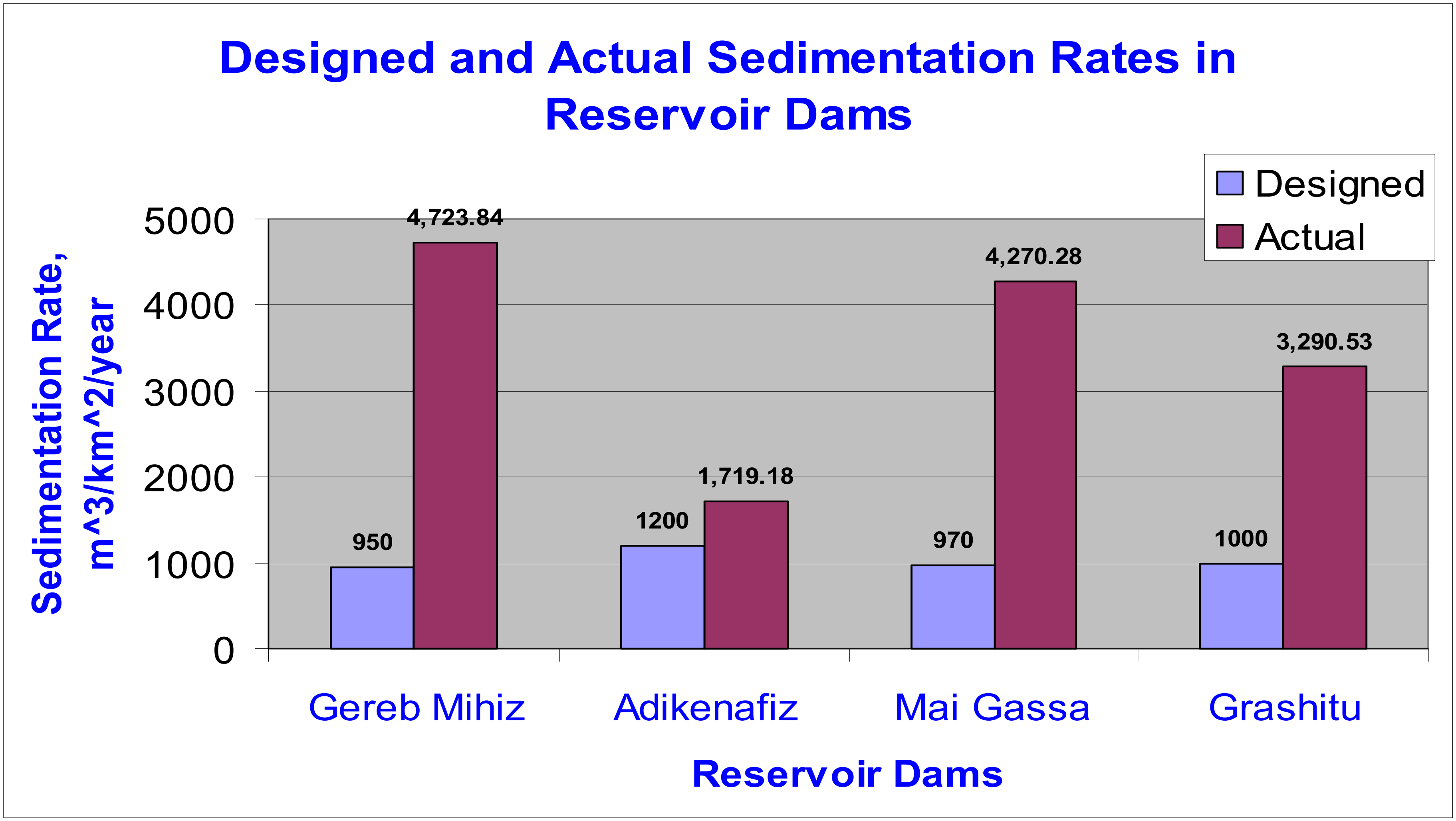
Research Issues for Sustainability

- ➔ Biological soil conservation measures with high economic return to the upland farmer
- ➔ Nutrient content of sediment deposited in reservoir
- ➔ Reclamation of degraded land for agriculture using sediment from reservoirs
- ➔ Interfacing scientific and indigenous climate forecasting techniques to enhance agricultural production.
- ➔Sharing benefits obtained from irrigation between irrigators and upland farmers
- ➔ Marketing of agricultural produce

➔ Proportion of cost recovery/sharing required from the direct beneficiaries

Details of the Research Issues

Determination of reservoir sedimentation rate and its mitigation measures



The problem to be addressed

- Estimation of Sedimentation Rate
- Mitigation Measure
  - SWC measure were not observed in bringing a significant economic benefit to the people whose livelihood is connected directly with the catchment areas.
  - the farmers have to wait for a long period before the first harvest and;
  - the yield is too low.

Expected yield from biological SWC measures, as outlined in the Awash basin master plan,

a. Fuel wood

- ➔from hill side closure : 10 m^3/ha after 20 years;
- ➔from conservation forestry : 75 m^3/ha after 20 years;
- ➔from community woodlot : 100 m^3/ha after 8 years.
-
- b. Fodder production
- ➔from conservation forestry and woodlot 0.2 ton/ha for initial 2 years;
- ➔from hillside closure 0.5 ton/ha for entire period

Could The Upland Farmers Get Benefit in the Short Term ?

- Could there be a fast growing, high yielding and nutritious fodder grass or shrub that can grow under harsh environment. The harsh environment could be explained in terms of little rainfall and long dry period, poor soil fertility and shallow depth, etc.
- What kind of fast growing flowering shrubs can be introduced to enhance apiculture? Shrub varieties with different period and length of flowering can be considered.
- Could there be a benefit sharing mechanism between down stream water users and care takers of the watershed.

Supplementary Irrigation as the Center of Maximizing Water Productivity

- ➢ What should be the minimum size of a water harvesting structure that would ensure food security at household level?
- ➢ What should be the least allowable ratio of irrigable area to inundated area?
- ➢ What should be the least allowable ratio of storage capacity to earth fill volume in embankment ponds?
- ➢ What kind of low cost seepage control technologies can be applied in the ponds?
- ➢ Would it be more beneficial to use the harvested water for double cropping than supplementary irrigation only?

Minimum Size of a Water Harvesting Ponds For House Hold Food Security

Table Expected Yield Increment Attributed to Supplementary Irrigation

Using Ponds, @ Adigudom

Data : Average Wheat Yield at Adigudom (1995---2000) = 2 to 16 qt/ha

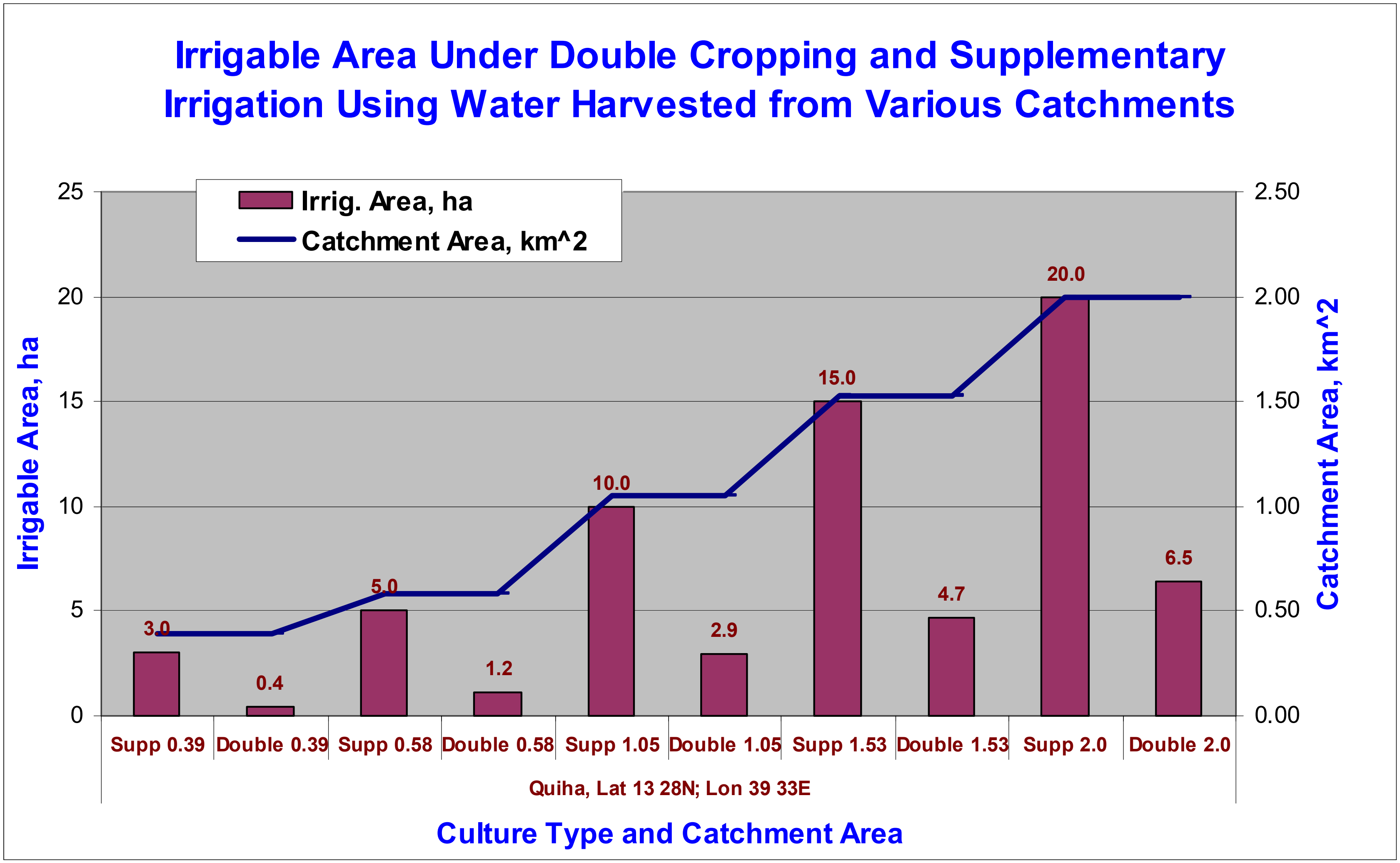
Potential Wheat Yield 30 60 qt/ha

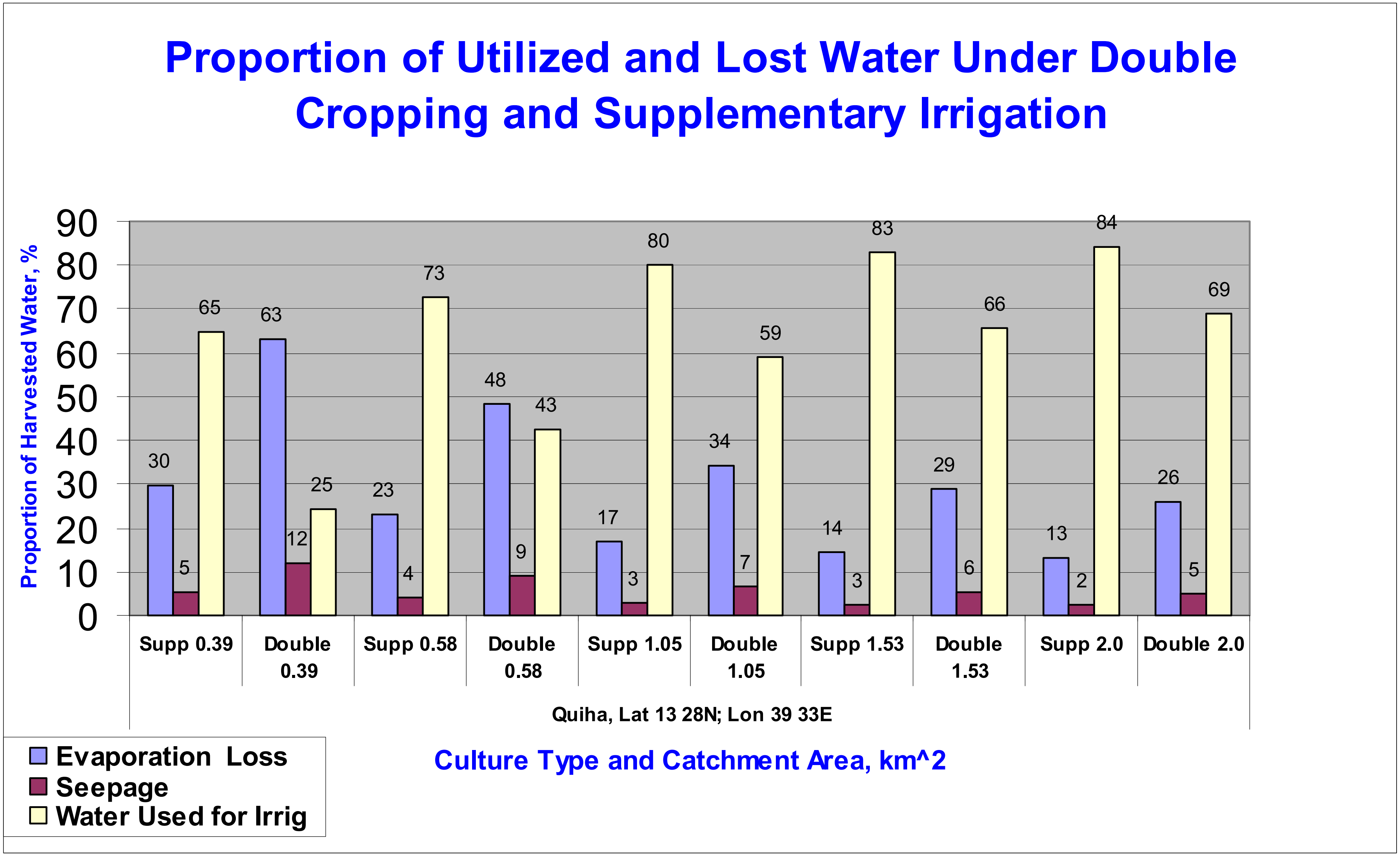
Area	Current Production		No. of Supplementary Irrigations & % of Associated Yield Increment					
			1	2	3	4	5	6
Ha	Minimum	Maximum	64.14	69.32	75.84	84.28	87.19	89.28
	qt	qt						
			Production in quintals @ 30 qt/ha as the Potential Yield					
0.05	0.1	0.8	0.96	1.04	1.14	1.26	1.31	1.34
0.1	0.2	1.6	1.9	2.1	2.3	2.5	2.6	2.7
0.2	0.4	3.2	3.8	4.2	4.6	5.1	5.2	5.4
0.4	0.8	6.4	7.7	8.3	9.1	10.1	10.5	10.7
0.5	1	8	9.6	10.4	11.4	12.6	13.1	13.4
0.6	1.2	9.6	11.5	12.5	13.7	15.2	15.7	16.1
0.8	1.6	12.8	15.4	16.6	18.2	20.2	20.9	21.4
1	2	16	19.2	20.8	22.8	25.3	26.2	26.8
2	4	32	38.5	41.6	45.5	50.6	52.3	53.6
3	6	48	57.7	62.4	68.3	75.9	78.5	80.3
4	8	64	77.0	83.2	91.0	101.1	104.6	107.1
5	10	80	96.2	104.0	113.8	126.4	130.8	133.9

What Should be the Least Allowable Ratio of Irrigable Area to Inundated Area?

- Financial Analysis
- Social & Political Dimension
  - What will happen if food deficiency persists and food aid is stopped?

Maximizing Water Productivity by Reducing the Proportion of Evaporation and Seepage Losses




Proportion of Utilized and Lost Water Under Double Cropping and Supplementary Irrigation
Proportion of Harvested Water, %
90
80
70
60
50
40
30
20
10
0
30
5
65
63
12
25
23
4
73
48
9
43
17
3
80
34
7
59
14
3
83
29
6
66
13
2
84
26
5
69
Supp 0.39
Double 0.39
Supp 0.58
Double 0.58
Supp 1.05
Double 1.05
Supp 1.53
Double 1.53
Supp 2.0
Double 2.0
Quiha, Lat 13 28N; Lon 39 33E
Culture Type and Catchment Area, km^2
Evaporation Loss
Seepage
Water Used for Irrig

Effect of Excessive Dewatering of Shallow Wells on Productivity of Grassland

- **to balance the mining and the rate of ground water recharge,**

In the Conveyance System

- Topographic Advantage for Using Piped Flow for Conveyance and Distribution
  - ➔ Average elevation difference between the reservoir outlet and the end of the supply canal in 11 irrigation projects is 1.15m per 100m. The slope of the field, perpendicular to the supply canal, is often more than 1%.
    - – Thus, gravity being the source of energy to drive the flow, there could be a good demand for pipes and drip laterals if the price is attractive to the small scale subsistence farmer.

Research at the Irrigable Area

1. Water Use Efficiency in a Field with 5-15m Furrow Length
2. Irrigation under Water Scarcity

Future Strategy in the Tekeze Basin

- Tekeze Basin Master Plan
  - Dams to be built for Hydropower Development
  - Large Scale Irrigation @ Lowland (>40,000 ha)
  - High Land Part
    - Watershed management
    - Small scale irrigation

Conclusion

- Irrigation development Possible
    - ➔ through water harvesting
    - ➔ requires the design and construction of various hydraulic structures.
- Irrigation Design Work should yield
    - ➔ stable and less expensive structure that would enable to obtain maximum benefit per unit volume of water.
- Thus, design work needs to be based on locally tested procedures wherever applicable.


THANK YOU